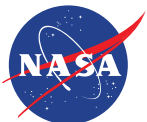




Complexity-Based Link Assignment for NASA's Deep Space Network for Follow-the-Sun Operations



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David Brown, Kenneth Roffo, and Carlyn Lee**
SpaceOps 2018 — Marseilles, France

Overview

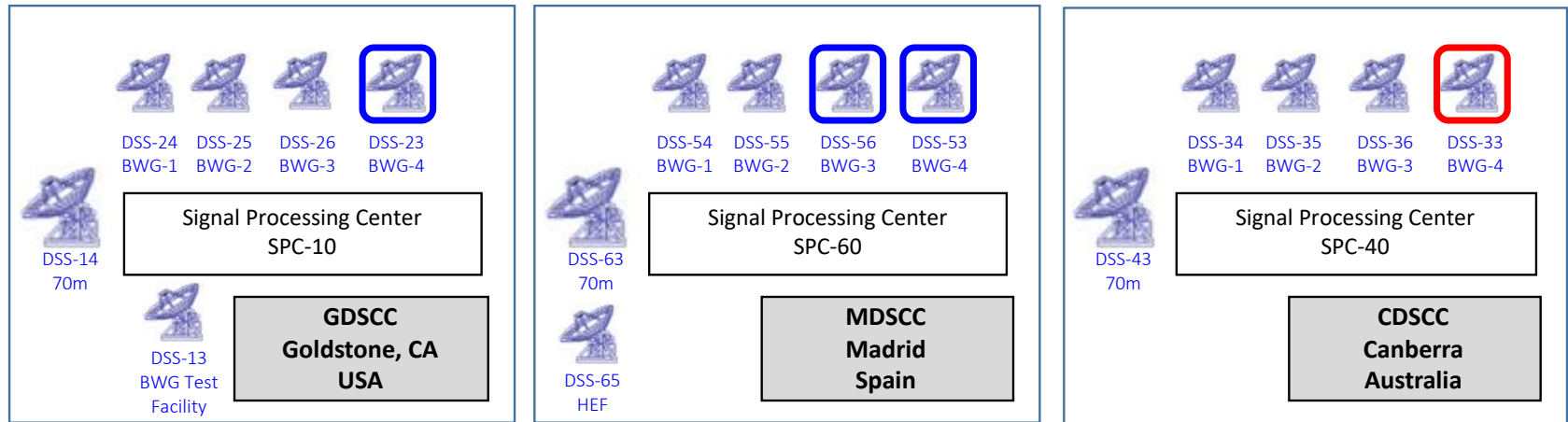
- Deep Space Network (DSN)
- Follow-the-Sun Operations – Paradigm Shift
- Role of Complexity-Based Link Assignment
 - architecture
 - interfaces
 - functionality
- Deployment and Status
- Conclusions

Deep Space Network (DSN)

- Network of 34- and 70-meter antennas in California, Madrid, and Canberra
 - All deep space missions use DSN for communications and navigation
- DSN is currently oversubscribed
 - 35 missions / science users dependent on DSN services
 - Limited network assets
 - Multi-use equipment (antenna testing / maintenance, calibration, science users)
- Small satellites represent new customer base for network



Deep Space Network Complexes and Antennas



New Antennas Not Completed Yet



Why complexity-based link assignment?

- Prior to Follow-the-Sun Operations (FtSO), each complex controlled 24x7 only their own 4 or 5 antennas



Why complexity-based link assignment?

- After the FtSO transition, each complex controls the **entire** network during their shift — making work assignments more challenging!



Solution

- **Decision support software for Link Control Operators (LCOs) at the DSN complexes to manage workload and breaks**
 - **LCM = Link Complexity and Maintenance Software**

<p>Primary objective: assign links to operators automatically or interactively, considering:</p>	<ul style="list-style-type: none">▸ complexity profile of activity during link, from setup through end of teardown▸ limits on number of links per operator and on maximum complexity per operator▸ special rules for high intensity link phases such as 3- and 4-MSPA links, and MMS1/2/3/4 spacecraft transitions
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Solution

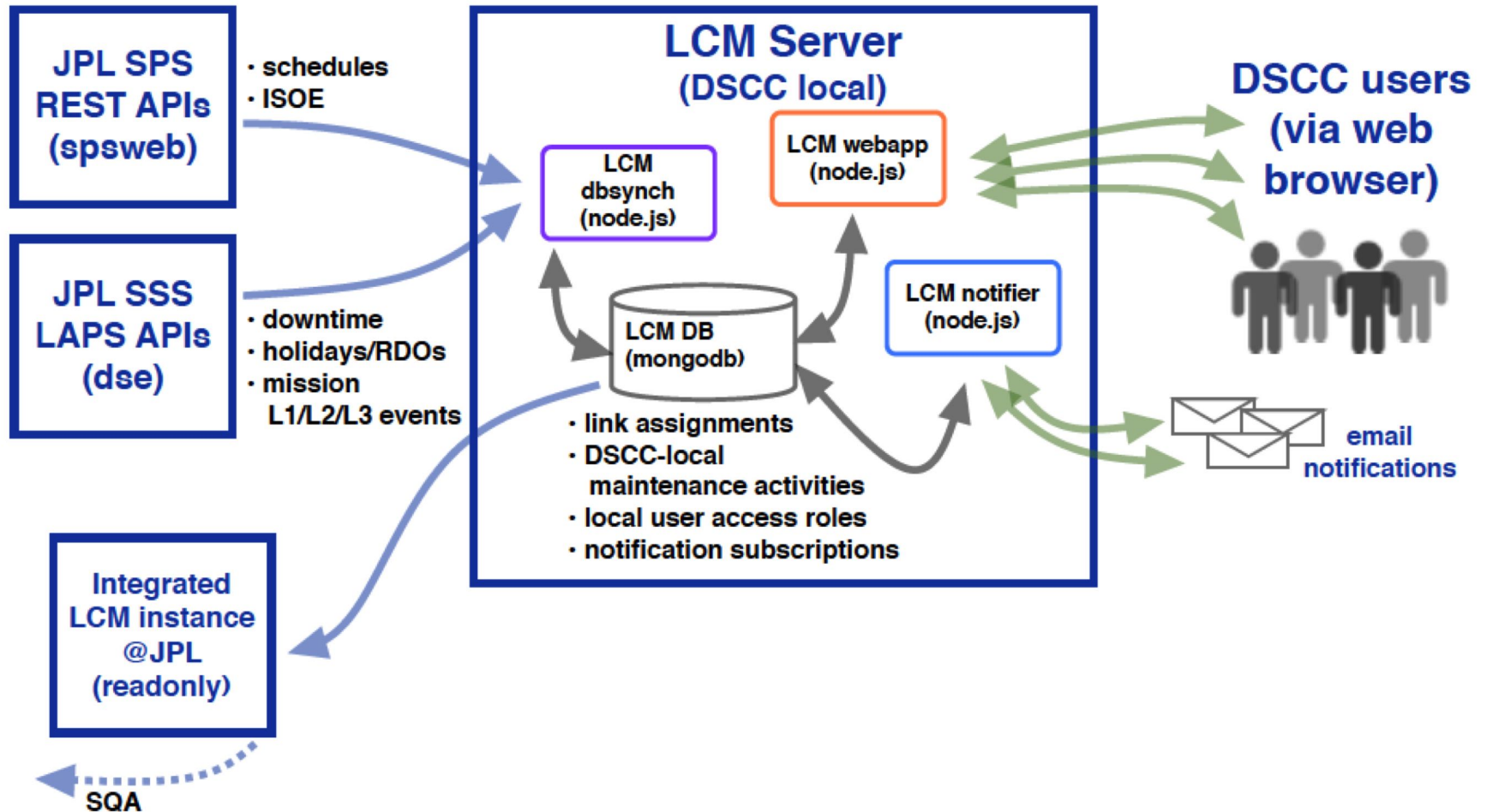
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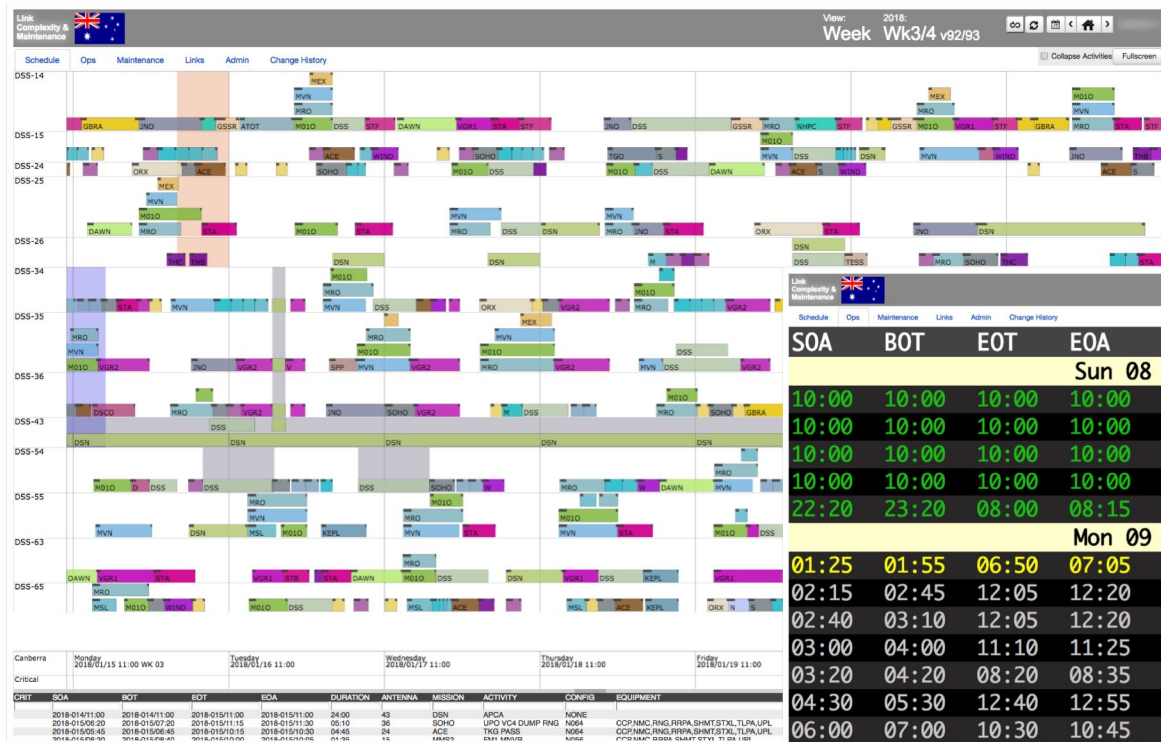
- complexity profile of activity during link, from setup through end of teardown
- limits on number of links per operator and on maximum complexity per operator
- special rules for high intensity link phases such as 3- and 4-MSPA links, and MMS1/2/3/4 spacecraft transitions

Secondary objective: support scheduling of site-local maintenance activities within allocated DSN maintenance windows

LCM Context

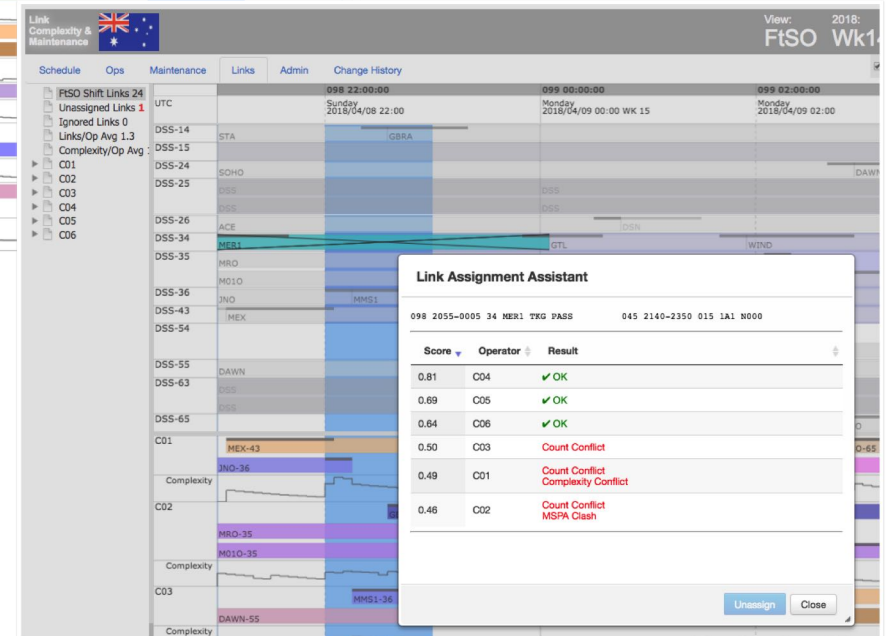
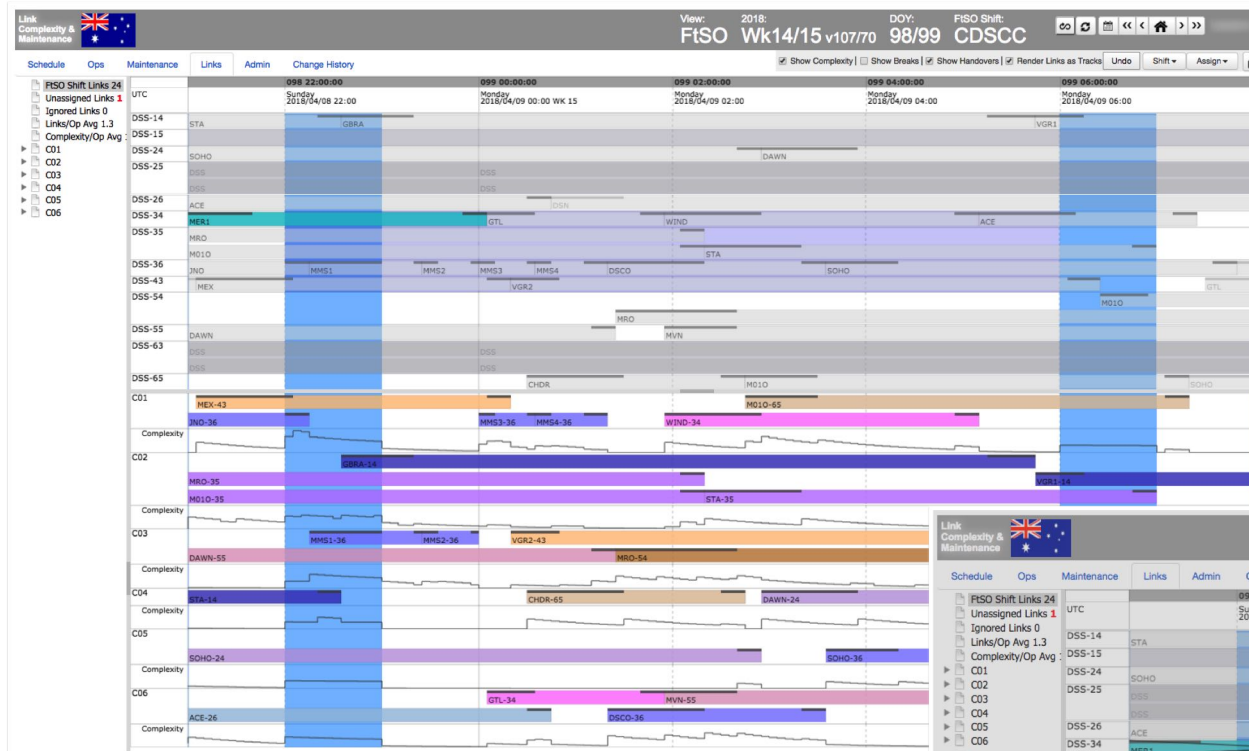


Schedule Displays



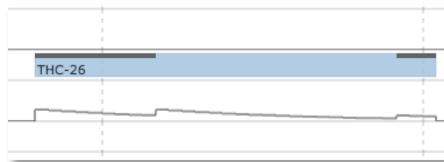
Link Complexity & Maintenance		View: 2018 FISO Wk14/15 v107/70		DOY: 98/99 FISO Shift: CDSCC		Full Screen	
Schedule	Ops	Maintenance	Links	Admin	Change History		
SOA	BOT	EOT	EOA	DSS	USER	ACTIVITY	OPERATOR
Sun 08 Apr - Week 14 Version 107							
10:00	10:00	10:00	10:00	63	DSS	EPOXY GROUT	-
10:00	10:00	10:00	10:00	63	DSS	APCA	-
10:00	10:00	10:00	10:00	25	DSS	MASER REPLC	-
10:00	10:00	10:00	10:00	25	DSS	AZ TRK REPLC	-
22:20	23:20	08:00	08:15	36	JNO	TKG PASS	C01
Mon 09 Apr - Week 15 Version 107							
01:25	01:55	06:50	07:05	43	VGR1	SCIENCE	Out Of Shift
02:15	02:45	12:05	12:20	35	M010	MX3	C02
02:40	03:10	12:05	12:20	35	MRO	MW22 2100UN120	C02
03:00	04:00	11:10	11:25	55	DAWN	TKG PASS	C03
03:20	04:20	08:20	08:35	14	STA	SSR PB/UNATT 720	C04
04:30	05:30	12:40	12:55	24	SOHO	UPO VC4 DUMP RNG	C05
06:00	07:00	10:30	10:45	26	ACE	TKG PASS	C06
06:55	07:40	09:50	10:05	34	MER1	TKG PASS	Unassigned!
07:05	08:05	10:05	10:20	43	MEX	T/P RS	C01
08:15	09:00	09:20	09:25	36	MMS1	ENG PASS	C03
08:35	09:20	15:15	15:45	14	GBRA	DEVEL_EGG0	C02
09:25	09:35	09:55	10:00	36	MMS2	ENG PASS	C03
10:00	10:10	10:30	10:35	36	MMS3	ENG PASS	C01
10:00	10:00	10:00	10:00	25	DSS	AZ TRK REPLC	-
10:00	10:00	10:00	10:00	63	DSS	APCA	-
10:00	10:00	10:00	10:00	63	DSS	EPOXY GROUT	-
10:00	10:00	10:00	10:00	25	DSS	MASER REPLC	-
10:05	10:35	11:40	11:55	34	GTL	TR DUMP 131S	C06
10:20	10:50	16:05	16:25	43	VGR2	SCIENCE	C03
UTC: 098 15:29:10				NEXT PRECAL: -00:45:50			
GDSCC: Apr 08 08:29		CDSCC: Apr 09 01:29		MDSCC: Apr 08 17:29			

Link Assignment and Assist Dialog

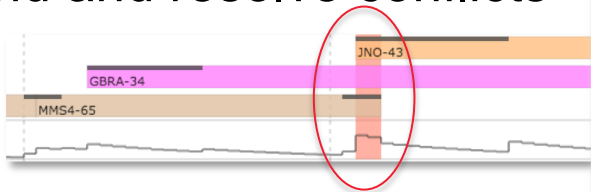


Features

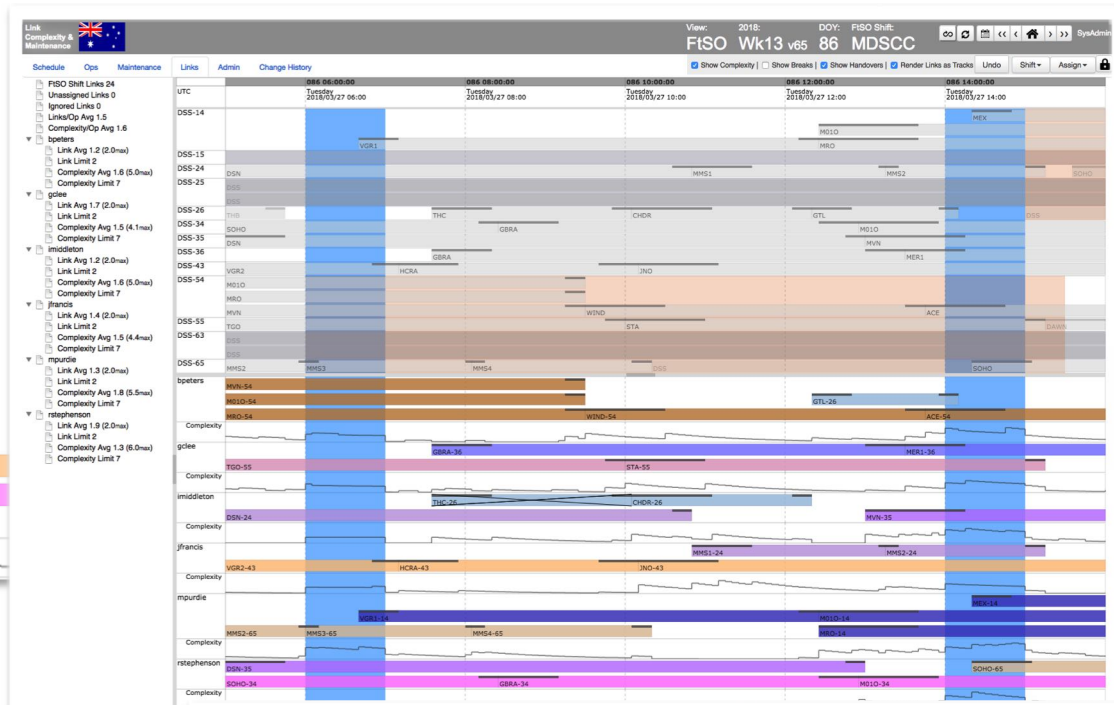
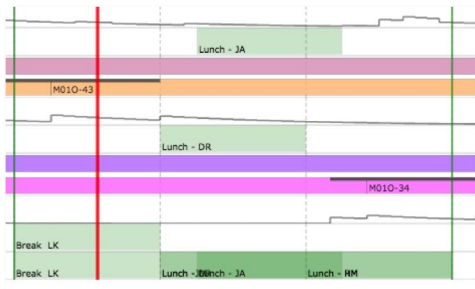
- Assign links to operators
- Model complexity profiles



- Find and resolve conflicts

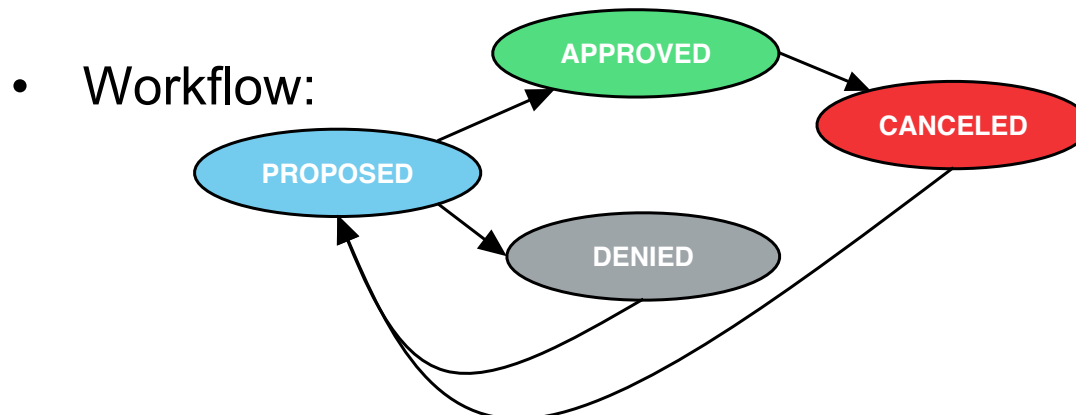
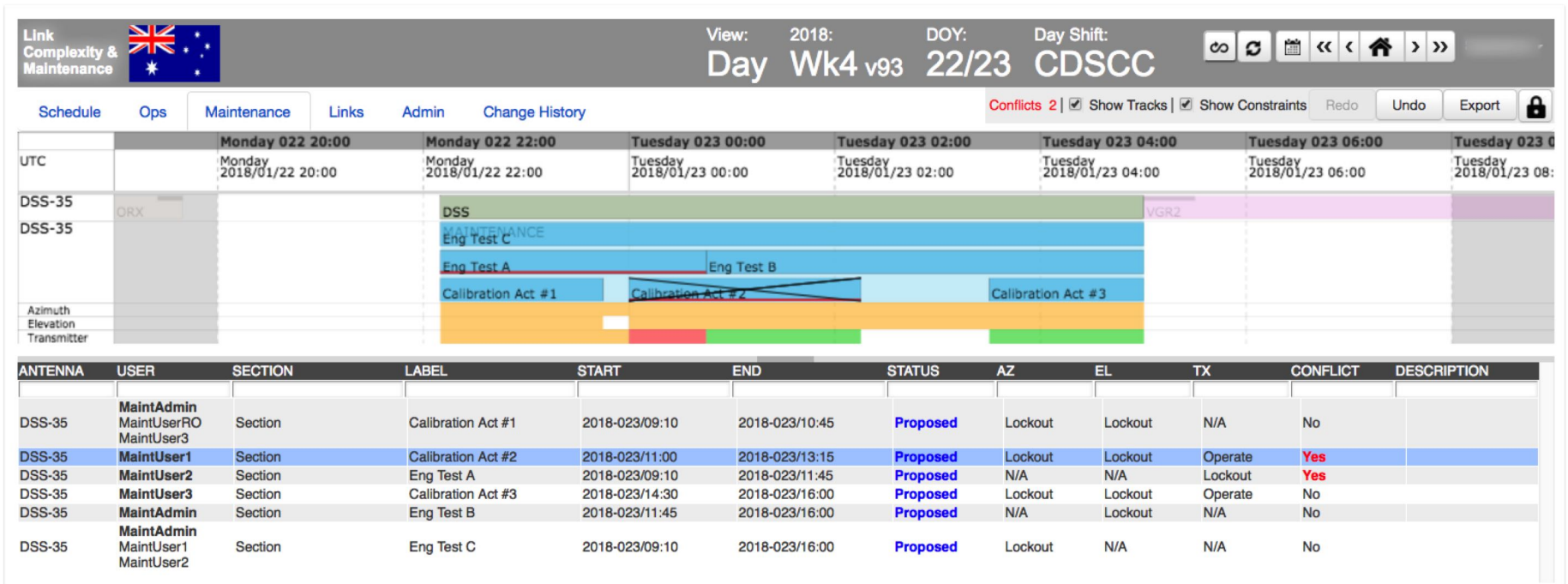


- Support break planning



SOA	BOT	EOT	EOA	DSS	USER	ACTIVITY	OPERATOR
Mon 26 Mar - Week 13 Version 65							
00:00	00:00	00:00	00:00	25	DSS	MASER REPLC	-
00:00	00:00	00:00	00:00	63	DSS	APCA	-
00:00	00:00	00:00	00:00	63	DSS	EPOXY GROUT	-
00:00	00:00	00:00	00:00	25	DSS	AZ TRK REPLC	-
10:05	10:50	19:40	19:55	54	SOHO	UPO VC4 DUMP	koger
10:15	11:15	19:10	19:25	34	JNO	TKG PASS	jada
11:15	12:15	21:45	22:00	35	ORX	TKG PASS	jada
13:05	14:20	20:25	20:25	36	MVN	MC11	martiniv
15:00	15:45	21:45	22:00	55	KEPL	MINI	rmurray
15:40	16:10	00:55	00:55	36	MRO	MC23 202SUN120	martiniv
16:10	16:40	18:40	18:40	36	MEX	MCX5	martiniv

Maintenance Planning



Status

Supervisor Station



**Deployed and operational
at all 3 DSCCs prior to
FtSO transition – Nov 2017**

Link Control Operator

